be forgotten that one of the functions of the Association is to inspire belief and confidence in science as the chief formative factor of modern life, and not only to display discoveries or enable specialists to discuss technical advances in segregated sections. Though members of the Association may be able to live on scientific bread alone, most of the community in any place of meeting need something more spiritual to awaken in them the admiration and belief which beget confidence and hope. They ask for a trumpet-call which will unite the forces of natural and social science, and are unmoved by the parade of trophies of scientific conquests displayed to them. It was the primary purpose of Canon W. V. Harcourt, the chief founder of this Association and its general secretary from 1831 to 1837, to sound this note for "the stimulation of interest in science at the various places of meeting, and through it the provision of funds for carrying on research," and not for "the discussion of scientific subjects in the sections." In the course of time these sectional discussions have taken a prominent place in the Association's programme, and rightly so, for they have promoted the advancement of science in many directions; but, while we recognise their value to scientific workers, we plead for something more for the great mass of people outside the section-rooms, for a statement of ideals and of service, of the strength of knowledge and of responsibility for its use. These are the subjects which will quicken the pulse of the community and convert those who hate and fear science and associate it solely with debasing aspects of modern civilisation into fervent disciples of a new social faith upon which a lever made in the workshops of natural knowledge may be placed to move the world.

Integration in the Living Organism.

By PROF. W. M. BAYLISS, F.R.S.

THE name "organism," given to the individual units of living matter as they are met with in Nature, implies that these act as unified and co-ordinated entities. At the same time, it must be remembered that an organism considered apart from its environment is merely a theoretical abstraction; but, apart from the way in which they react to external influences, there must be means by which the activity of any one part is adjusted to the needs of the whole, and the investigation of these various means may be said to form a large part of modern physiology. In a general sense, it may be looked upon as distinctive of the more recent outlook, for most of us are not content with ascribing the mutual co-ordination of function to a presiding directive agency, be it called "entelechy," "élan vital," or other mysterious influence. We want to know more of the actual chemical and physical methods at work in the process, and we believe that it is possible to find out a great deal more about them than we know as yet. The change in the point of view of the physiologist may be realised better if we call to mind that it is no longer thought scientific to devote attention to the "functions of the liver," for example, but to those processes, such as deamination and regulation of carbohydrate supply, in which this organ plays a part in combination with various other tissues of the organism. We ask: What part does the liver play in the correlated series of changes associated with the using up of the materials of the food for the supply of energy to, and for the growth of the cells of, the organism as a whole?

Broadly speaking, there are two great "systems"—to use a term which is rather antiquated in this sense—that serve as the means of communication between different parts of the higher animals—the nervous system and the vascular system. There are corresponding means of communicating by messages or by actual transport of materials in the higher plants. As a first approximation, we may call the former physical and the latter chemical. These correspond to the "nervous" and "humoral" factors of the French physiologists. The central nervous system, in addition to its obvious function of receiving impressions from the outer world and reacting upon it by reflexes to muscles, obtains messages from the various parts of the organism itself by means of appropriate receptors therein. Thus "effectors"—muscles, glands, etc.—are modified in their activity, and the special requirements of active organs are met. For example, an active secreting gland receives an increased supply of blood, containing sugar and oxygen, by dilatation of the blood vessels to it. By the blood, or similar circulating liquid, a chemical substance made in one place is carried over the whole of the organism, and in special places adjusted to be sensitive to it brings about appropriate reactions, which may affect a large number of other organs. Thus the carbon dioxide produced in active muscles reaches the respiratory nervous centre, exciting this to increase the ventilation of the lungs and supply more oxygen to the muscles by means of the blood.

The comparison of the nervous system to the telegraphic circuits of a city has often been made, and is probably more to the point than is sometimes thought, since there are many reasons for supposing that the passage of impulses along nerves is essentially of an electrical nature. The vascular system may similarly be compared to mechanical transport, by which coal, for instance, is conveyed in carts. In this latter case, material substances are sent from place to place. Perhaps a closer analogy to the blood vessels with their pump, the heart, would be the distribution of water in pipes; but everyday experience reminds us that there is also a postal system by means of which actual material bodies convey *messages*. Thus a letter can order a supply of coal or cut off the electric current. The "chemical messengers" or "hormones" are the letters of the living organism. When the acid contents of the stomach pass into the intestine a chemical compound of unknown constitution is formed in the cells lining this tube, passes into the blood, and ultimately arrives at the pancreas, the cells of which alone of all those with which the blood comes into contact are able to respond to its stimulus. This they do by secreting pancreatic juice. The hormone, called "secretin," merely to give it a name, is a letter sent to the pancreas by the food asking for the enzymes needed to digest it. It does not serve in any sense as food for the cells, it is not a part of the secretion, but sets the machinery to work.

The fact must not be overlooked, however, that these various means of integration act together. Just as coal can be ordered by telegram, so a supply of sugar or oxygen can be ordered by a nervous message sent by an active organ, and we have already seen that a chemical messenger (=a letter) can excite the respiratory centre to send nervous impulses (=telegraphic messages) to the muscles producing respiratory movements. In general, co-ordination by chemical means is apt to be of a more prolonged or continuous nature than that by nervous reflexes. Even in the latter case, however, it is very common to find that an organ is under the continuous control of both excitatory and inhibitory nerves, the two opposing influences being in action at the same time. Any particular state is thus the expression of a preponderance on one or the other side of the balance. The fact has been made clear in the tone of the stomach of some reptiles, but it appears to be of wide occurrence, if not a general law.

The internal secretions of the endocrine glands are to be included in the category of chemical messengers. An interesting and instructive article by Prof. Strohl, of Zürich, was published in the *Revue générale des Sciences* (May 15, 1921), and, in point of fact, suggested the present remarks. His article deals with the general biological significance of the internal secretions, and contains a full list of papers, including those concerning lower animals. The author compares hormones to the electric waves of wireless telegraphy, since only certain tissues are tuned to respond to them. I venture to think that the postal system is a better illustration. Actual material bodies are carried, and these "letters" are accepted only at the correct addresses. In many cases, such as those of the suprarenal bodies and the thyroid gland, we are able to assign the function in question definitely to particular organs, which, indeed, appear to possess no other function.

In other cases, more difficulty is met with, owing to the fact that the cells producing the internal secretion are mixed up with cells having other known functions. Such, for example, is the case with the "islets of Langerhans," embedded in the pancreatic tissue which secretes the digestive juice. There is evidence that these "islets" produce a hormone which is required for the due utilisation of sugar. This co-existence, side by side, of cells with different functions is only one of the many difficulties met with in the study of internal secretions. It appears that removal of one particular endocrine organ affects the functions of those that are left. Indeed, the complexity of the phenomena may be some excuse for the contradictory and hazy statements so often made by workers on the problem, and for the hasty and sensational "discoveries" announced from time to time in the Press. This aspect of the subject is rightly emphasised by Gley in his valuable lectures on "Les Sécrétions Internes," where it is pointed out that clear and definite statements are much to be desired. Names are too often given which, although they profess to explain, are nothing but descriptions of the facts in other words. No advance is possible in this way.

The existence of certain organs or tissues which, so far as can be made out, have no function other than that of making chemical compounds for the purpose of acting on other tissues suggests the question whether those tissue cells which have obvious functions of another kind do not also give out to the blood substances which act in other places—whether the view of Brown-Séquard that all tissues make internal secretions may not be correct. In the simple case of carbon dioxide this is, of course, the case; but it is possible that many of the chemical products of the activity of cells may be inert for want of receptive cells sensitive to them. Many substances found in animals and plants appear to be waste products of metabolism—as, for example, the great variety of alkaloids met with in plants. There is evidence that some influence is exerted by cells on the growth and nature of cells of other kinds in their neighbourhood. The experiments of Champy may be cited as examples of this influence; moreover, fragments of differentiated tissue grown on a slide under the microscope are apt to lose their distinctive marks as they proliferate, and to become of an embryonic type. If, however, the fragment contains both epithelium and connective tissue, the new epithelial cells retain the characters of those from which they arise, so long as they remain in proximity to the connective tissue; but if they wander away they lose their identity and become generalised in aspect. Similarly, the excessive outgrowth of connective tissue in retinal fragments is held in check by the presence of nerve cells. It seems that the normal growth of tissue cells is only possible when under the "control" of other cells. This circumstance is significant in relation to the problem of malignant growths. Champy describes a case of a particular tumour which was found on removal to be only in part malignant, but when a culture was made of the epithelium of the normal part the cells, deprived of the influence of their surrounding tissues, gave rise to daughter-cells similar to those of the malignant growth.

Again the power of survival of transplanted organs shows how complex is the variety of factors distinguishing one individual from another even within the same species. Prof. Leo Loeb has made a large number of experiments of this kind in the United States, and finds, in agreement with other workers, that tissues transplanted into another species die more or less rapidly; if put into another individual of the same species they also die in the end, but not so soon as in the first case. If simply moved into another part of the body of the same individual they survive and grow. In some cases they may survive in the body of an individual closely related to that from which the tissue was taken—as, for example, a brother. Now while Prof. Loeb assumes that the results are chiefly due to the giving off by the cells of specific chemical entities which differ from individual to individual, we must remember that we have no actual proof of this. It is perhaps well to be cautious until the specific properties are shown to be of a chemical nature. An interesting fact is that the specificity spoken of reaches this high state of development only in the higher vertebrates, and is much less manifest in their embryonic stages.

The hypothesis that all constituent cells of an organism give off internal secretions is clearly at the basis of hormone theories of heredity, such as that associated with the name of J. T. Cunningham. However inaccessible to influence of other kinds, it cannot be denied that the germ-plasm must be exposed to the action of substances in solution in the blood. The experiments of Stockard show that the germ-plasm in guinea-pigs is altered for several generations by the action of alcohol on the original parents. The removal of an organ, such as the tail, containing merely tissues abundantly present elsewhere would not be expected, on this hypothesis, to have any effect capable of hereditary transmission.

The internal secretions, especially those affecting growth, have an obvious resemblance to the accessory food factors or vitamins; but these have to be supplied to animals from the outside, ultimately from vegetable food, since plants only are able to make them. In neither case, however, do we know the chemical nature of the substance concerned. It may turn out that we have to do with minute traces of metallic elements, perhaps some of the rare metals. In that connection we are reminded of the necessity for zinc, in extremely small amounts, for the optimal growth of the mould Aspergillus. Certain of the endocrine organs may, indeed, have the function of supplying in an active or utilisable form some particular element, as appears to be the case with the thyroid gland in relation to iodine.

"Leader" Cables for Aircraft.

FOR some time past experiments have been in progress in adapting to the purposes of aerial navigation the "leader" cable system now successfully used in connection with shipping. Various tests made in this country revealed that a marine installation is of little use to aircraft, as no signals were received from the cable whilst an aeroplane was over the submerged part of it. But when the land portion of the cable was reached the signals it gave out were heard easily in the machine through an ordinary telephonic receiver. If the cable be laid above ground, or suspended from poles, the "leader" system can be employed as successfully to guide aircraft as to guide shipping. The principle is the same in each case, though some modifications in applying it are necessary.

So far as England is concerned, we do not appear to have gone much beyond demonstrating the fact that a "leader" cable for aircraft is a practical proposition. But Lieut. Loth, of the French navy, after devoting a considerable period to investigating the subject, has devised an aircraft "leader" cable which proved highly successful when tried at the Villacoublay aerodrome. This officer is well known for his work in connection with such cables, as he was largely responsible for laying the marine installation at Brest. His aerial apparatus follows closely upon the lines of that employed in ships. Three receiving coils are fixed on the aeroplane, and the pilot takes in signals by means of "listeners," or ear-pieces, in his helmet. When the machine is flying directly above, or parallel to, the cable a strong signal is transmitted to the pilot through the centre coil, and this continues so long as the cable is being "followed." The other coils indicate when the machine is to right or left of the cable, and enable the pilot to "pick up" the installation. Signals can be heard at an altitude of 10,000 ft. and for a mile and a half on either side of the cable.

In the case of a submarine cable, the area over which sound can be heard is necessarily limited, because a good deal of energy is expended in producing currents in sea water. In the air no such loss of energy occurs, and therefore the sound-range can be very materially increased. "Leader" cables fulfil the same function in relation to aircraft as to seacraft by enabling them to find their way home in thick weather or in the dark, and by adopting the system the practice of lighting flares on aerodromes is made unnecessary.